A Silvicultural Guide For Hybrid Poplar in Ontario

Ministry of Natural Resources
Ontario

Hon. Alan W. Pope
Minister

W. T. Foster
Deputy Minister

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A SILVICULTURAL GUIDE
FOR HYBRID POPLAR
IN ONTARIO

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Brockville
1983

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PREFACE

This Silvicultural Guide is a documentation of the technology currently accepted as standard practice for the successful establishment of hybrid poplar plantations. This technology evolved as a result of technology development trials, practical experience gained in preparing, reviewing and implementing annual operating plans, and evaluation of the outcome of these plans when implemented. Input has come from research scientists, forest specialists, management foresters and technicians. This guide is not intended to be a review of all pertinent scientific literature and cited references have been kept to a minimum. The Scientific Review publication provides substantial documentation of the science of the Hybrid Poplar Program (Armson 1983).

It is impossible, in a guide, to cover every different situation which can affect the establishment of a plantation. One of the major pitfalls in preparing a guide is that it may be used improperly. Forest managers work within a complex biological system. They must carefully assess each situation and exercise a considerable degree of judgement, skill and knowledge in developing and implementing prescriptions.

Finally, the technology documented in this guide is constantly undergoing review. It is anticipated that new practices, herbicides, treatments, and clones will continue to be introduced each year, providing further gains in productivity and increased efficiency. The Fast Growing Hardwoods Staff Group, Brockville, can be consulted for additional information and updates on the latest developments in technology.

It has been five years since the "New Forests in Eastern Ontario" program was initiated in 1978. During that period of time, the hybrid poplar technology, which has been developed and applied, has gained an international reputation as a successful program of intensive forest management.

1.0 INTRODUCTION

Research into hybrid poplar has been carried out at various periods, over the last 40 years in Ontario. The majority of the work has focused on breeding and the production of interspecific hybrids with rapid growth rates. Many standard European cultivars were imported in the late 1960's for test plantings. The results of this work indicated a tremendous potential for productivity.

The first serious attempts at establishing production plantations of hybrid poplar were made in the late 1960's and early 1970's in eastern Ontario. The impetus for this program came from:

- an available landbase of 600,000 ha of marginal agricultural land, abandoned from farming -400,000 ha of this identified as being suitable for hybrid poplar
- a serious, developing shortage in the supply of pulp wood in eastern Ontario - 65% of the wood supply must be imported into the region
- the presence of a pulp and paper industry of considerable socio-economic importance to the region, contributing over $100 million annually into the local economy
- a keen interest expressed by industry and Ministry of Natural Resources personnel.

Early plantation culture was limited by a number of factors. Originally, only two hybrid poplar clones were available for planting. No consideration was given to the specific soils of the planting site and no attempt was made to match the clones to site. Site preparation and weed control were totally mechanical, and only partially effective. The resulting plantations were very inconsistent. Outstanding successes were offset by dramatic failures, often within the same plantation area. From this early work, several key observations were made:

- soils on the plantation site had to be carefully mapped and described and clones had to be matched carefully to the prevalent soil conditions
- complete site preparation and weed control was necessary for good survival and growth
- the soil requirements of different clones vary considerably
- the genetic base of the program needed to be expanded to provide suitable clones capable of growing on a wider range of sites.

The technology development program initiated in 1978 set out to answer the basic questions of where and how to grow hybrid poplar, and to explain some of the observed inconsistencies in growth. A general outline of the steps involved in establishing a plantation is given in Figure 1. Site preparation provides a good example of how the program's standard

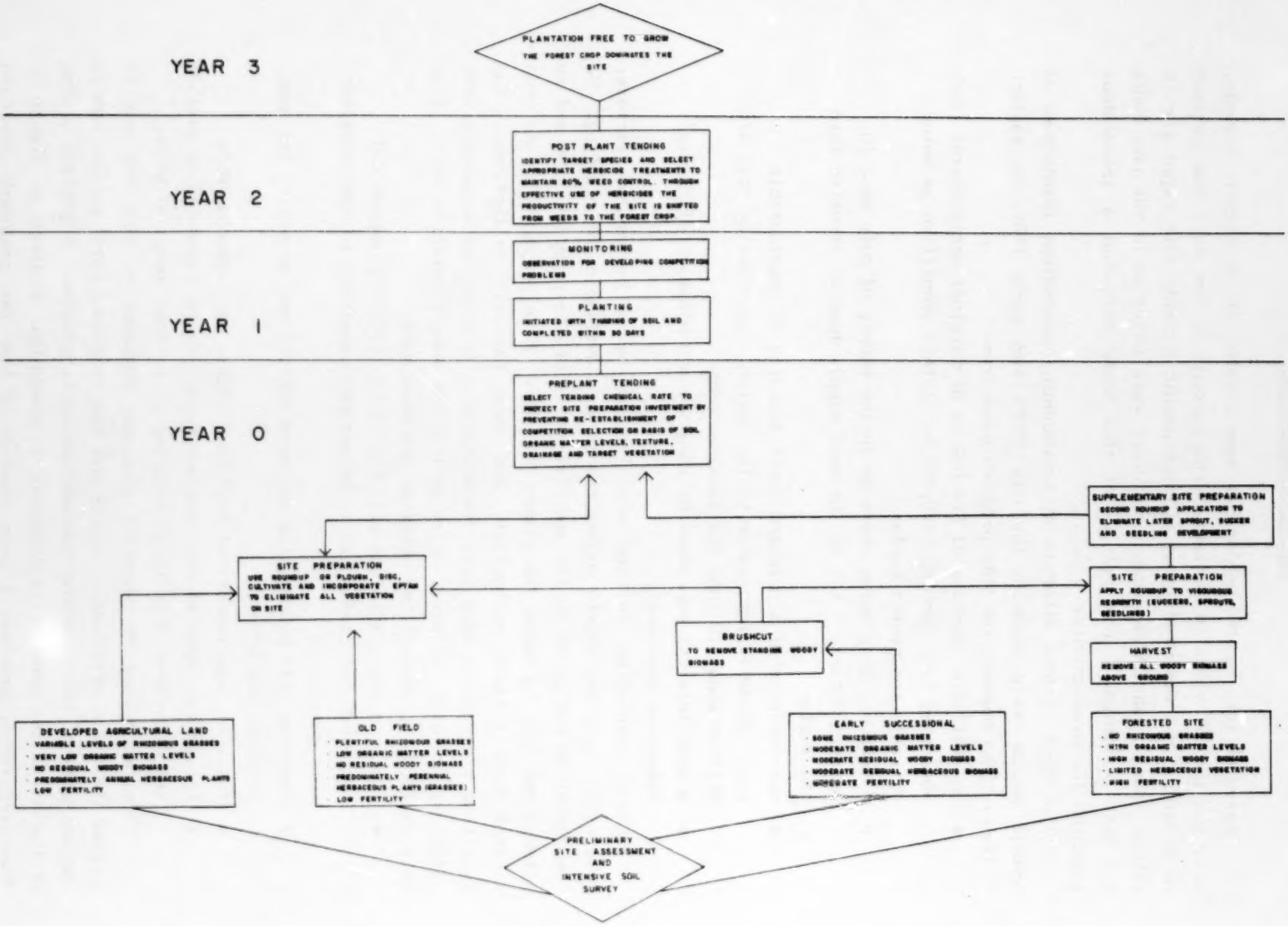
YEAR 3
PLANTATION FREE TO GROW
THE FOREST CROP DOMINATES THE SITE
YEAR 2
POST PLANT TENDING
IDENTIFY TARGET SPECIES AND SELECT APPROPRIATE HERBICIDE TREATMENTS TO MAINTAIN 80% WEED CONTROL THROUGH EFFECTIVE USE OF HERBICIDES THE PRODUCTIVITY OF THE SITE IS SHIFTED FROM WEEDS TO THE FOREST CROP
MONITORING
OBSERVATION FOR DEVELOPING COMPETITION PROBLEMS
YEAR 1
PLANTING
INITIATED WITH THAWING OF SOIL AND COMPLETED WITHIN 30 DAYS
YEAR 0
PREPLANT TENDING
SELECT TENDING CHEMICAL RATE TO PROTECT SITE PREPARATION INVESTMENT BY PREVENTING RE-ESTABLISHMENT OF COMPETITION SELECTION ON BASIS OF SOIL ORGANIC MATTER LEVELS, TEXTURE, DRAINAGE AND TARGET VEGETATION
SUPPLEMENTARY SITE PREPARATION
SECOND ROUNDUP APPLICATION TO ELIMINATE LATER SPROUT, SUCKER AND SEEDLING DEVELOPMENT
SITE PREPARATION
USE ROUNDUP OR PLOUGH, DISC, CULTIVATE AND INCORPORATE EPTAM TO ELIMINATE ALL VEGETATION ON SITE
SITE PREPARATION
APPLY ROUNDUP TO VIGOUROUS REGROWTH (SUCKERS, SPROUTS, SEEDLINGS)
BRUSHCUT
TO REMOVE STANDING WOODY BIOMASS
HARVEST
REMOVE ALL WOODY BIOMASS ABOVE GROUND
DEVELOPED AGRICULTURAL LAND
· VARIABLE LEVELS OF RHIZOMOUS GRASSES
· VERY LOW ORGANIC MATTER LEVELS
· NO RESIDUAL WOODY BIOMASS
· PREDOMINATELY ANNUAL HERBACEOUS PLANTS
· LOW FERTILITY
OLD FIELD
· PLENTIFUL RHIZOMOUS GRASSES
· LOW ORGANIC MATTER LEVELS
· NO RESIDUAL WOODY BIOMASS
· PREDOMINATELY PERENNIAL HERBACEOUS PLANTS (GRASSES)
· LOW FERTILITY
EARLY SUCCESSIONAL
· SOME RHIZOMOUS GRASSES
· MODERATE ORGANIC MATTER LEVELS
· MODERATE RESIDUAL WOODY BIOMASS
· MODERATE RESIDUAL HERBACEOUS BIOMASS
· MODERATE FERTILITY
FORESTED SITE
· NO RHIZOMOUS GRASSES
· HIGH ORGANIC MATTER LEVELS
· HIGH RESIDUAL WOODY BIOMASS
· LIMITED HERBACEOUS VEGETATION
· HIGH FERTILITY
PRELIMINARY SITE ASSESSMENT AND INTENSIVE SOIL SURVEY

Figure 1: Establishment of hybrid poplar plantations in Ontario

practices have been developed. Much of the technology used for site preparation, including that for herbicides, has been adopted with some modification from agriculture. Farming equipment is used to till the sites and agricultural literature provides information on the most effective herbicide to control a particular weed species. Well designed and statistically sound herbicide trials determine the ranges of application rates which provide effective weed control without harming the tree crop.

1.1 The Genetic Base

The world gene pool of Populus species is well represented in the plantation clones currently used in Ontario. The most commonly used principal species and crosses are listed in Table 1. The 'DN' clones form the largest group of hybrids and were the first clones used for planting. In a period of ten years, the number of clones in production has increased from two to the present level of more than 150. More recently, a number of aspen- and balsam-type hybrids (eg. 'AK 41' and 'NM 1') have been brought into production.

TABLE 1

LISTING OF MAJOR POPLAR SPECIES AND CROSSES CURRENTLY IN PRODUCTION *

Species and Crosses	Example of Clone
P. x canescens x alba x grandidentata	CAG 204
P. alba	A 499
P. alba x glandulosa	AK 41
P. alba x grandidentata	AG 212
P. alba x sieboldii	AS 31
P. grandidentata x alba	GA 88
P. x canescens	C 147
P. deltoides	D 38
P. x euramericana	DN 2
P. deltoides x nigra	DN 55
P. nigra	DN 90
P. deltoides x trichocarpa	DTAC 27
P. angulata	Z 13
P. angulata x trichocarpa	DTAC 32
P. nigra x maximowiczii	NM 1
P. x jackii	JAC 4
P. x jackii x nigra	JACN 5
P. maximowiczii x deltoides	MD 1
P. generosa x jackii	3C29
P. generosa x serotina	8/33A
P. angulata x berolinensis	DTAC 1
P. trichocarpa	TRICH 22

* This list is not all-inclusive.

A broad genetic base provides a tremendous amount of valuable genetic diversity. This results in reduced risk of large losses in productivity to insects or diseases. The diversity of species and the resulting hybrids also provide the opportunity of establishing plantations on a wider range of site conditions. The genetic base of the Hybrid Poplar Program is dynamic. On an annual basis ten new clones are introduced into production, while ten older clones with poorer growth performance or pest resistance are removed from production. Some of the more recent clones have a productivity 400% greater than that of the original clones first used in the program.

In 1979 a tree improvement program was initiated to select the native poplar species which could be used in a breeding program to develop new clones. The constant turnover of clones is an important and continuing process which parallels the strategy used in agriculture to maintain rust-resistance in wheat. Each new strain of wheat produced eventually loses its rust resistance and new resistant strains must continually be developed to replace the older ones - usually every five years. This strategy is responsible for maintaining wheat as a viable crop.

2.0 ORGANIZATION

The establishment and management of a hybrid poplar plantation requires that a carefully timed sequence of operations be carried out within a narrow time span. This is particularly true of the site preparation phase. Failure to successfully complete one of the operations will usually have an adverse effect on the remaining schedule of operations and result in reduced plantation performance. In many situations, it may be possible to modify the remaining prescription and still achieve the desired end result - a successful plantation - but the ability to do this depends upon:

- preparing a plan of operations detailing the necessary sequence of operations
- implementing the operations properly and in a timely fashion
- evaluating each treatment to verify that the desired result has been achieved - this implies a clear understanding of what are considered acceptable results
- responding when necessary by modifying the prescription in accordance with the changed situation
- maintaining flexibility to implement modifications quickly.

A modification to the prescription may be as simple as repeating a single operation (eg., discing) or adding a completely new treatment (eg., supplementary herbicide). Careful monitoring of operations combined with a flexibility to implement necessary modifications will afford the best opportunities for success.

2.1 Records

A well maintained and detailed set of records is a basic requirement for highly intensive forest management. Hybrid poplar is managed on a compartment rather than a project basis. The silvicultural treatments are primarily based upon the current state of the plantation, but must also consider previous treatments to the site. The selection of a herbicide treatment to control a particular target species must take into account whether or not that same herbicide was previously applied and what chemical residues may already be on-site. The intensive soil survey provides an appropriate base map for such records. Information on treatments, specifications followed, dates, modifications to original prescriptions, and the results observed through close monitoring, will provide a valuable documention of "what has been done", and will guide future operations.

2.2 Monitoring

Comprehensive monitoring of treatment areas and the status of other plantations is necessary in order to quickly identify those areas requiring additional treatments. The intensity of monitoring may range from one inspection per growing season for older, free-to-grow plantations, to a number of visits within the same week for those areas under active site preparation. Monitoring is only effective if the results are carefully scrutinized and appropriate action is taken where needed. Given the short rotations associated with hybrid poplar, the delay of a critical treatment such as weed control, by even one year, may significantly reduce overall plantation yields.

3.0 SILVICULTURAL OPERATIONS

There are a series of key operations leading to the successful establishment of a hybrid poplar plantation:

- soil surveying and site selection
- thorough site preparation to eliminate all competition on the site
- proper matching of clones to site
- maintenance of weed control until the plantation is free-to-grow.

The common sequence of operations is illustrated in Figure 1 for hybrid poplar grown on a 10-year rotation.

The establishment of a hybrid poplar plantation requires a substantial investment in site preparation and tending. In conventional conifer plantation establishment the major emphasis is on the use of high quality nursery stock, with a minimum amount of site preparation. By contrast, hybrid poplar plantations are established on totally prepared sites with complete competition control. The full potential of the site to support tree growth is made available. Genetic improvement in poplar is aimed at producing clones capable of growing rapidly, utilizing the available resources of the site, and with a resistance to frost, insects and disease. The unrooted poplar cuttings used for planting represent a small part of the input to the site, but contain the essential genetic information required to produce a clonal stand.

4.0 PRELIMINARY SOIL SURVEY

The preliminary soil survey determines which particular sites on a compartment are suitable for growing hybrid poplar. Each individual clone tends to have a unique set of highly specific site requirements. However, when the entire group of clones is considered collectively, a fairly broad range of site conditions is covered. This reflects a broad genetic base comprised of several species from different geographic regions around the world. These species in turn have been combined to form many different interspecific crosses, with highly diverse characteristics.

As a general rule, extremes in soil conditions should be avoided, eg., extremely fine-textured, massive soils and very coarse sands and gravel (Table 2). For practical purposes hybrid poplar can be subdivided into three groups with somewhat similar site requirements; the cottonwood-type, the aspen-type and the balsam-type hybrids. Generalizations on site requirements of clonal groups should be viewed cautiously, given the great variation which often exists even between clones of related parentage.

4.1 The Cottonwood-Type Hybrids

This group tends to be the most demanding in terms of site requirements. These cottonwood-type clones require large volumes of water but are intolerant of poor soil aeration. Loams and well structured silt loams with good fertility levels can be considered good sites. Soil pH values should be 7.0 or higher.

4.2 The Aspen-Type Hybrids

Poplar sites in the drier range of the drainage spectrum are favoured by the aspen-type hybrids. The root systems tend to be quite extensive with many deeply penetrating sinker roots. Growth is best on sandy loam and loamy sand soils with pH levels less than 7.0.

4.3 The Balsam-Type Hybrids

Hybrids in this group tend to be relatively tolerant of extremes in site conditions, such as poor aeration. Selected clones from this group have been used for reclamation of acid mine spoils and disturbed sites. Best growth is associated with imperfectly-drained, fine-textured soils.

TABLE 2

KEY SOIL REQUIREMENTS FOR HYBRID POPLAR

	Good	Acceptable	Not Acceptable
Texture	- loams - sandy loams - well-structured clay and silt loams	- loamy sand - clay loams - silt loams	- coarse sands - massive fine textured soils
Structure	- well developed	- amorphous or single grain	- massive soils lacking structure
Drainage	- imperfectly drained	- moderately well drained	- excessively well drained - very poorly drained
Soil pH	7.0+	5.5 to 8.5	less than 5.5
Soil depth	greater than 75 cm	45 cm to 75 cm	less than 45 cm

5.0 INTENSIVE SOIL SURVEY

A highly intensive soil survey of sites deemed suitable for hybrid poplar, provides essential information needed to make decisions on the establishment and management of the plantation. Soils information at a scale of 1:4000 provides sufficient detail for most management decisions. Soils are considered when selecting herbicides and their rates, mechanical treatments, and when scheduling operations and allocating clones to site.

The intensive soil survey delineates and describes the different soil types present on the area. Soil types are mapped on the basis of differences in texture, drainage, depth, parent materials, stoniness and pH. A complete and objective soils profile description and diagram is prepared to accompany the soil survey map, completing the documentation of the site (Figure 2). The complete soil survey procedure is fully documented elsewhere (Armson 1983).

6.0 PRE-SITE PREPARATION ACTIVITIES

The overall operating conditions of a site can sometimes be improved prior to commencing site preparation operations. Abandoned farmland is often characterized by small fields which are awkward to operate on with large, modern, mechanized equipment. In these situations, operating costs may increase by as much as 20%. This is in addition to the loss of productive plantation land. Efficiency can be significantly improved by removing fence lines, stones and other barriers to operations.

6.1 Drainage

The objective of drainage is to remove standing water from the site during the active growing season. Standing water causes poor soil aeration resulting in reduced tree growth or mortality after extended periods of time. Herbicides are often leached from a position in the soil where they provide weed control, into the root zone of the tree crop, where they cause herbicide damage. Drainage done prior to crop establishment will improve the ease of carrying out subsequent operations by reducing the area of non-operable, wet depressions. Although water tables may also be lowered, the main objective is removal of surface water.

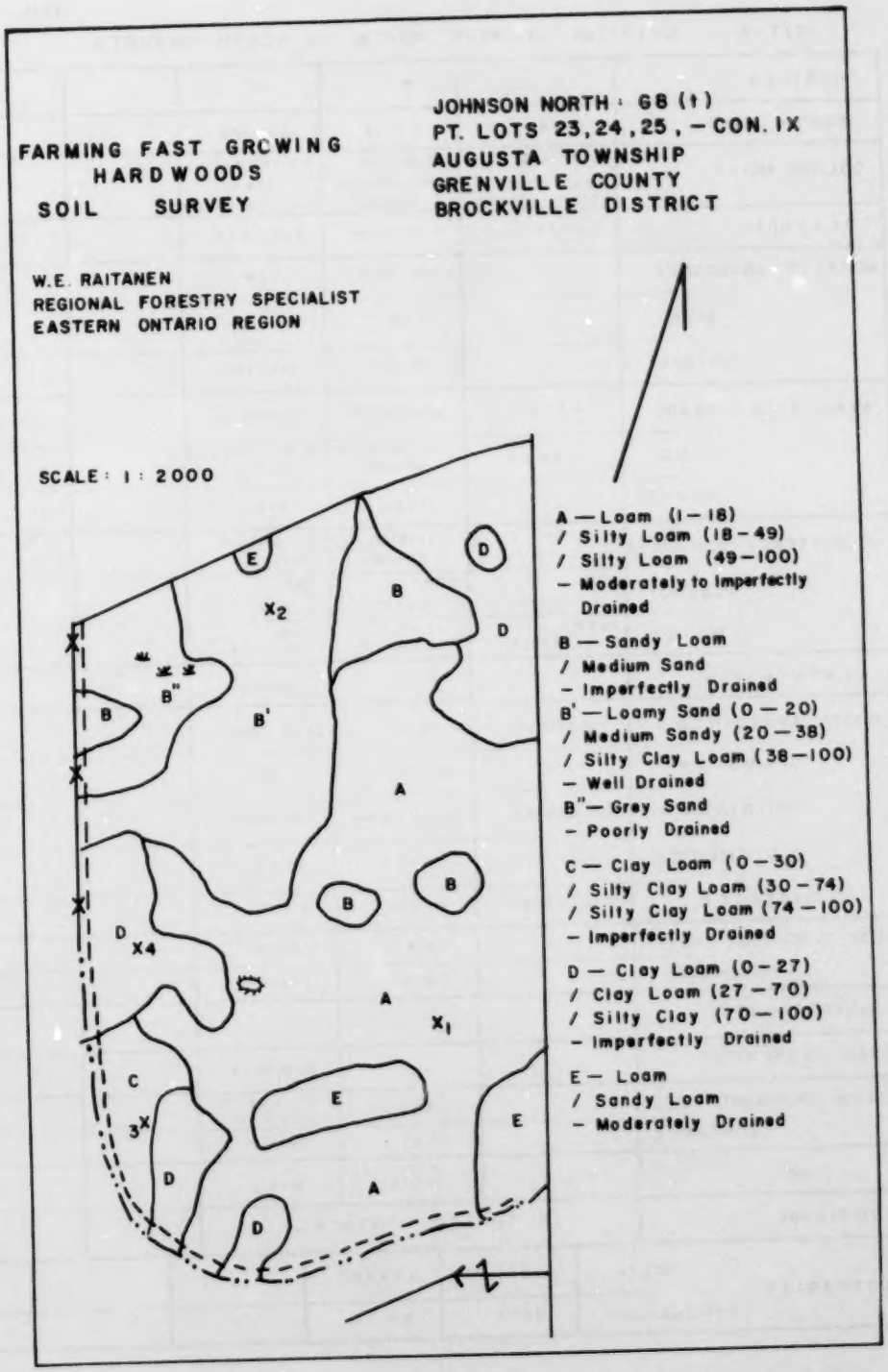
FARMING FAST GROWING
HARDWOODS
SOIL SURVEY
JOHNSON NORTH : 68 (1)
PT. LOTS 23,24,25, - CON. IX
AUGUSTA TOWNSHIP
GRENVILLE COUNTY
BROCKVILLE DISTRICT
W.E. RAITANEN
REGIONAL FORESTRY SPECIALIST
EASTERN ONTARIO REGION
SCALE : 1 : 2000
A — Loam (1 - 18)
/ Silty Loam (18 - 49)
/ Silty Loam (49 - 100)
- Moderately to Imperfectly Drained
B — Sandy Loam
/ Medium Sand
- Imperfectly Drained
B' — Loamy Sand (0 - 20)
/ Medium Sandy (20 - 38)
/ Silty Clay Loam (38 - 100)
- Well Drained
B" — Grey Sand
- Poorly Drained
C — Clay Loam (0 - 30)
/ Silty Clay Loam (30 - 74)
/ Silty Clay Loam (74 - 100)
- Imperfectly Drained
D — Clay Loam (0 - 27)
/ Clay Loam (27 - 70)
/ Silty Clay (70 - 100)
- Imperfectly Drained
E — Loam
/ Sandy Loam
- Moderately Drained

Figure 2a. A hybrid poplar soil survey map

SOIL TYPE: A

PIT 3 LOCATION : JOHNSON NORTH — NORTH AUGUSTA

HORIZON	Ap	Bt	Ck		
DEPTH (cm)	0-18	19 - 49	50-100		
COLOUR MOIST	10YR 3/2 VERY DARK GRAYISH BROWN	10 YR. 3/4 DARK YELLOW BROWN	2.5 YR. 4/2 DARK GRAYISH BROWN		
TEXTURE	LOAM	SILTLOAM	SILTLOAM		
MOTTLES - ABUNDANCE		VERY FEW	FEW		
SIZE		FINE	MEDIUM		
CONTRAST		FAINT	DISTINCT		
STRUCTURE — GRADE	WEAK	MODERATE	MODERATE		
KIND	CRUMB	SUB-ANGULAR BLOCKY	SUB - ANGULAR BLOCKY		
CLASS		FINE	FINE		
CONSISTENCE - STICKINESS	SLIGHTLY STICKY	SLIGHTLY STICKY	SLIGHTLY STICKY		
WET PLASTICITY	NON PLASTIC	NON PLASTIC	NON PLASTIC		
MOIST	VERY FRIABLE	VERY FRIABLE	VERY FRIABLE		
CEMENTATION			WEAK		
ROOTS ABUNDANCE	PLENTIFUL	FEW	VERY FEW		
DIAMETER	FINE	MEDIUM	FINE		
ORIENTATION	HORIZONTAL	HORIZONTAL	OBLIQUE		
DISTRIBUTION	INPED	INPED	EXPED		
SPECIES	HERBACEOUS	WOODY	WOODY		
CLAY FILMS - FREQUENCY		FEW	FEW		
THICKNESS		THIN	THIN		
CONCRETIONS					
FREE CARBONATES			MODERATE		
COARSE FRAGMENTS - SIZE		COBBLE	BOULDERS COBBLE		
ABUNDANCE		MANY	MANY		
pH	6.0	7.15	8.05		
DRAINAGE	IMPERFECTLY DRAINED				
BOUNDARIES WIDTH	ABRUPT	ABRUPT			
TOPOGRAPHY	WAVY	WAVY			

Figure 2b. A hybrid poplar soil profile description

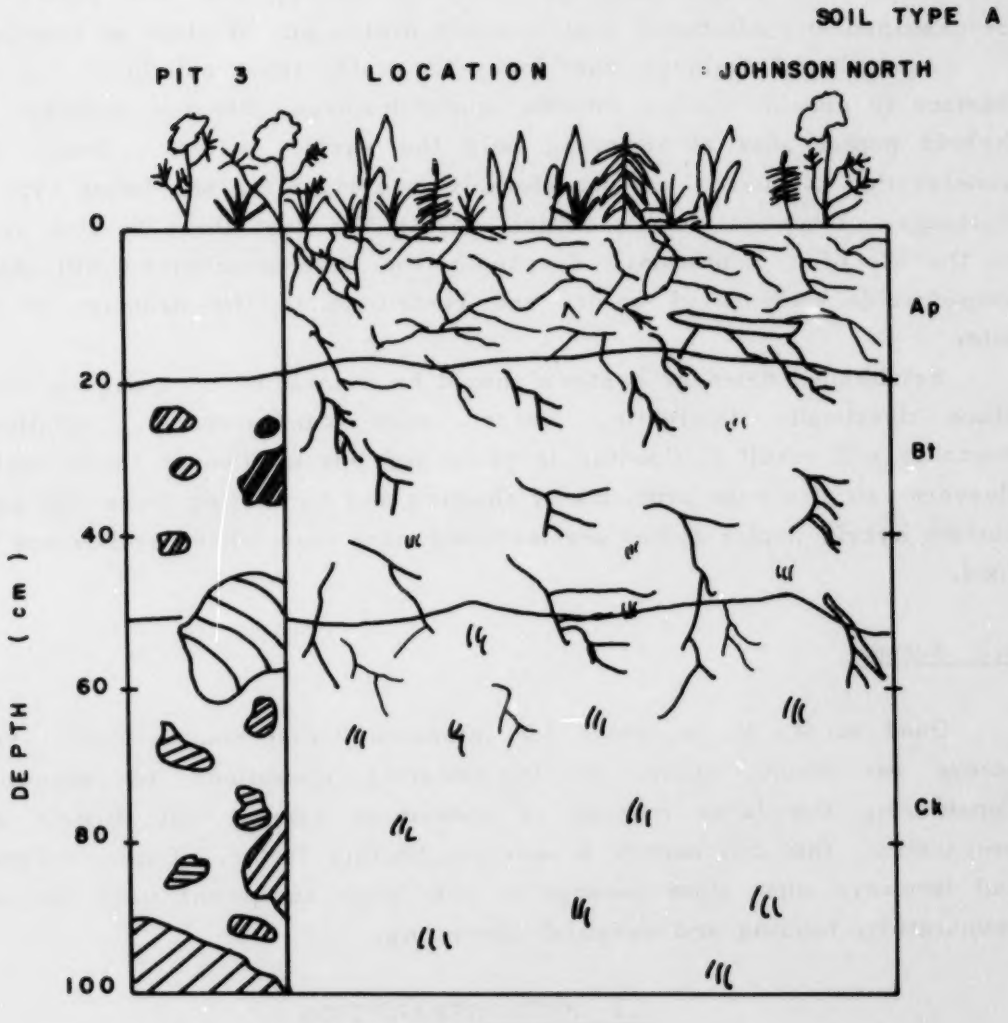

Figure 2c. A hybrid poplar soil profile diagram

Drainage is achieved using primary, secondary, or tertiary, open ditches. On many previously farmed sites the original drainage system can still be located and simply cleaned out. Tertiary drainage can be provided by aligning the furrows and "strike-outs" during ploughing to move the surface water into shallow ditches (secondary drains) which usually are located on one or more perimeters of the field. These shallow ditches, in turn, drain into the large primary drains. Once all mechanical site preparation has been completed, the site should be re-examined and additional small tertiary drains put in place as required.

Agricultural drainage must lower the water table well below the soil surface to provide outlets for tile under-drainage, whereas drainage for hybrid poplar aims at removing only the surface water. Design and construction standards are considerably less rigid for the latter type of drainage. Drainage is most critical during the first three to five years in the life of a plantation. Eventually the developing stand will utilize considerable amounts of water, and contribute to the drainage of the site.

Established drainage systems should be maintained on a regular basis since drastically fluctuating water tables can damage plantations. Mortality will result if flooding is prolonged beyond two or three weeks. Beavers can also pose problems by flooding and harvesting trees - in fact, certain hybrid poplar clones are favoured more than others by beavers for food.

6.2 Access

Good access is important for intensive forest management. Poor access can cause delays in implementing operations on schedule. Considering the large number of operations carried out during site preparation, this can become a severely limiting factor. Gates, culverts and laneways must allow passage of the large equipment used for site preparation, tending and eventual harvesting.

7.0 SITE PREPARATION

The primary objective of site preparation is to eliminate all weed and grass competition on the site prior to planting. Complete weed control allows the use of 25 cm long unrooted cuttings for the establishment of all but long rotation veneer plantations. The best plantation performance is realized when site preparation has been completed successfully. Good site preparation minimizes the amount of weed control operations required after planting. The development of a suitable prescription must be matched to the target weed species to be eliminated, the operating conditions on site, and the technical and

operational capabilities available. The greatest number of inputs in overall plantation establishment are made within a matter of weeks, during site preparation.

Site preparation technology is based upon two herbicides, Roundup[1] and Eptam[2], which provide the means for eliminating competing vegetation. Figure 3 illustrates the standard site preparation prescriptions. After analyzing the site and the competing vegetation, a prescription is selected and fine tuned for each situation, eg., a Roundup rate for brush versus that for grasses.

Timing is critical for successful implementation of a prescription. Failure to complete one operation on time will delay all subsequent operations. Many treatments are also highly state dependent, (eg., stage of vegetation development). Information on the herbicides and their use is carried on the product label.

7.1 Brush Cutting

The objective of brush cutting is to eliminate standing woody biomass which impedes mechanical operations or herbicide applications. On sites which are to be tilled, brush cutting will improve the quality of subsequent operations by breaking down the size of the debris. Rotary brush cutters leave the debris as coarse mulch on the site. This smaller sized material decays more rapidly, releasing nutrients which can be utilized by the plantation. Standing brush over one metre tall often hinders herbicide application, depending on the spraying equipment used. Tall brush is usually cut and allowed to resprout before spraying.

7.2 Ploughing

The objectives of ploughing are to:

- facilitate subsequent tillage operations by breaking up heavy sod layers
- thoroughly incorporate all organic matter throughout the plough layer
- break up any plough pans created by previous farming activities on the site.

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1 Roundup is a registered trade name of Monsanto Canada Incorp.

2 Eptam is a registered trade name of Stauffer Chemical Company of Canada Ltd.

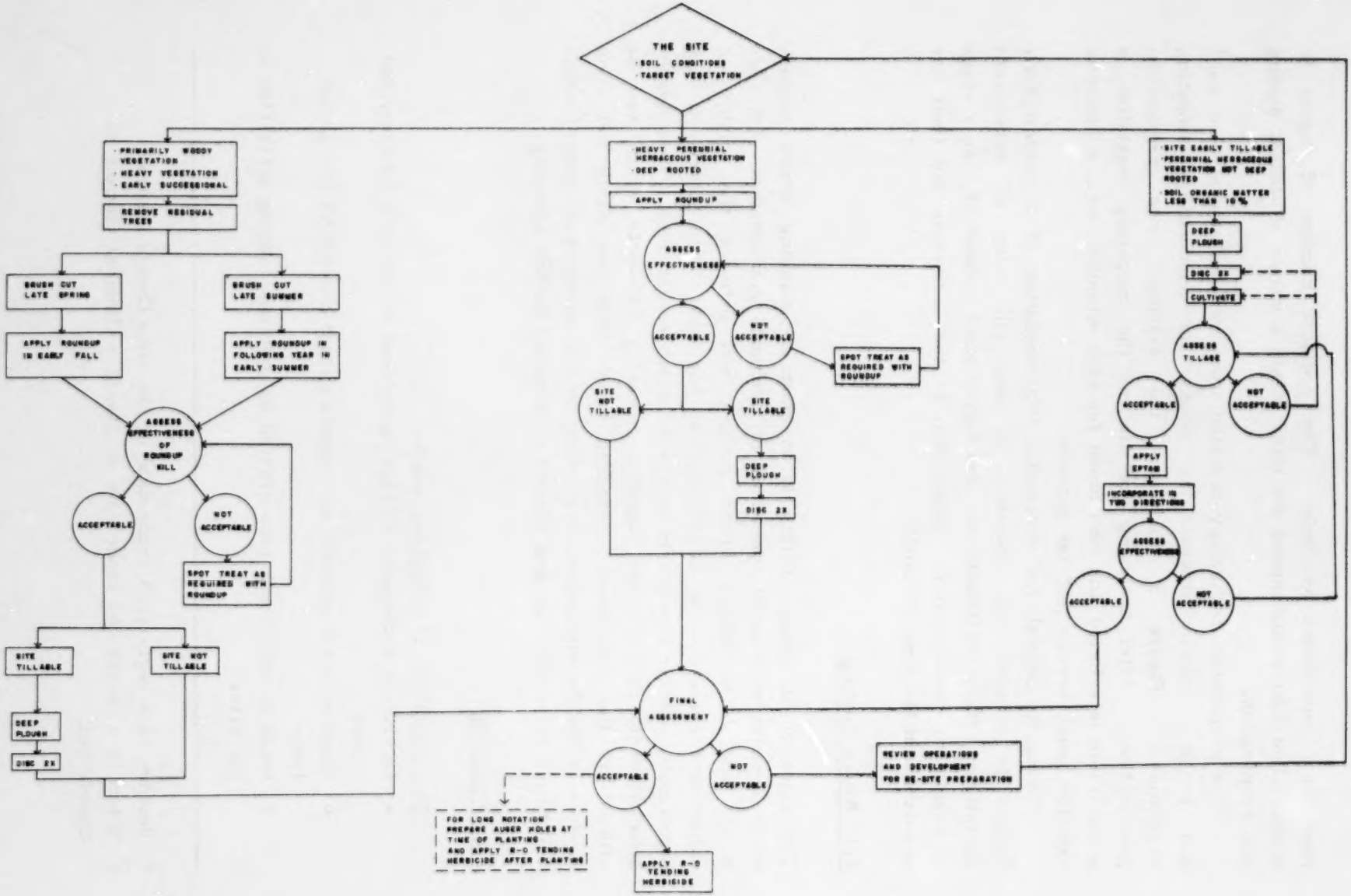

Figure 3: Operations and key decision points for basic hybrid poplar site preparation prescriptions

- provide a loose, well-aerated layer of soil to promote rapid early root development on the planted cuttings.

Notes on equipment:

- general purpose mouldboard ploughs, with wide bottoms, should be used to reach the necessary plough depth
- the number of furrows on the plough must be matched to the size of the prime mover and the type of soil.

Specifications for operations:

- ploughing should be 25 cm deep
- furrows should be completely turned over
- the number of dead furrows should be minimized due to problems in achieving good tillage on these strips
- furrows should be oriented on flat or gently sloping sites so as to encourage tertiary drainage.

Ploughing is usually done as soon as the site is operable at the beginning of the growing season. On sites where living vegetation is ploughed under, subsequent tillage operations are required within three weeks to prevent substantial regrowth of vegetation. Heavy regrowth of vegetation will hinder discing operations and may result in the need for additional cultivations or even re-ploughing. Heavy textured soils may benefit from fall ploughing; frost action over the winter will aid in breaking down the furrows.

7.3 Discing

The objectives of discing are to:

- break down furrows, sods and ploughed under vegetation on ploughed sites
- prior to Eptam application, to adequately break down sods and pieces of root system for effective killing of the vegetation by Eptam
- thoroughly incorporate organic matter throughout the plough layer
- provide a loose, well-aerated layer of soil for rapid early root development of planted cuttings
- provide a smooth and even soil surface for application of the Rising-O tending herbicide.

Notes on equipment:

- the disc is a series of concave discs mounted in two gangs designed to cut the soil - the front gang and back gangs are angled in opposite directions so as to throw the soil out with the front gang and in with the back gang
- the discs should be a minimum of 60 cm in diameter and heavy enough to cut to the required 20 cm depth
- the first pass of the discs is usually made in the same direction as the ploughed furrow to level the site.

Specifications for operations:

- discing done to a depth of 20 cm
- discing should be done alternatively at right angles - two discings are required as a minimum.

To achieve the same degree of tillage, fine-textured soils may require more discings than coarse-textured soils. Wet soils cannot be disced. On sites where the vegetation was killed prior to ploughing, good tillage is achieved with a minimum amount of discing. Large amounts of debris and stones will greatly reduce the effectiveness of the equipment. Discing should break down all pieces of sod or clods of soil, greater than 10 cm in size, on the surface of the site. On sites where heavy vegetation has been ploughed under, a cultivation between discings can greatly improve the quality of tillage.

7.4 Cultivation

The objectives of cultivation are to:

- provide an intermediate tillage operation between discings to improve degree of tillage on sites with heavy root masses
- provide an alternative tillage option for heavy-textured soils
- draw root systems and ploughed-under vegetation closer to the surface where discing can more effectively mulch the material into smaller pieces.

Notes on equipment:

- the cultivator consists of a set of teeth, slightly curved forward and usually spring mounted
- the cultivator tends to pull sod and vegetation to the surface - some discing is necessary prior to cultivation, otherwise the implement will become clogged
- heavy duty cultivators with spring loaded teeth may penetrate deeper than the lighter S-tined cultivators.

Specifications for operations:

- cultivations should be to a depth of 20 cm
- cultivation should be preceded by discing on all ploughed sites
- subsequent discings at a right angle to the direction of cultivation will finely chop sod and other pieces of vegetation brought to the surface by the cultivator.

Cultivation is used selectively and only when Eptam is used for site preparation. Under normal operating conditions, discing provides more thorough tillage. However, cultivation can bring roots and vegetation to the surface, resulting in more complete chopping up of the material by subsequent discings.

7.5 The Eptam Prescription

Eptam is a selective herbicide which is incorporated into fully tilled soil. It is activated by soil moisture and forms a gas, killing all living vegetation contacted in the soil. Eptam is effective against quack grass, most annual grasses and many broadleaved weeds. In the soil, the herbicide residue has a half life of one week.

Considerations in selecting the Eptam prescription:

- a prerequisite for the use of Eptam is thorough soil tillage - excessively stony sites or sites with a dense woody root mass are difficult to till and are not suitable for Eptam
- soil organic matter levels in excess of ten percent will significantly reduce the effectiveness of the herbicide
- Eptam can only penetrate loose, well-tilled soils
- On drier sandy sites, roots of perennials such as quack grass may extend well below effective tillage and herbicide incorporation depths and will therefore be unaffected by Eptam.

Specifications for use:

- thorough tillage to 20 cm depth; throughout the plough layer intact pieces of sod or clods should not exceed 10 cm in size
- weeds which have not been disturbed or which have become established on the site following the last tillage operation will not be controlled by Eptam
- sites should be ploughed as early as possible in the growing season to minimize the amount of fresh organic matter that is in the soil at the time of Eptam incorporation.
- root segments of rhizomous grasses (eg. quack grass) should consist of less than five segments or be less than 15 cm in length

- Eptam is applied at a rate of 8.8 kg active ingredient per hectare
- Eptam should be incorporated simultaneously with the application by discing to a depth of 20 cm. A second discing should be made at right angles and within a few hours to complete the incorporation.

7.6 The Roundup Prescription

Roundup is a broad spectrum, nonselective herbicide which is applied as a post-emergent spray to actively growing vegetation. The herbicide is absorbed through stems and foliage and translocated throughout the entire plant. Mortality of the entire plant occurs within two weeks. There is no residual activity in the soil.

Considerations in selecting the Roundup prescription:

- Roundup is very effective in eliminating deep-rooted perennials
- Roundup is a post-emergent herbicide, so its effectiveness is not affected by the success of tillage operations
- application must be timed to match susceptible periods for the target vegetation
- vegetation must be actively growing for proper translocation to occur within the plant. On highly variable sites, vegetation on dry knolls may be dormant while vegetation on the remaining areas is still active.
- rainfall within two hours of application may render the Roundup totally ineffective; rainfall within two to six hours will reduce its effectiveness considerably.

Specifications for use:

- timing of application must be based upon the target species to be controlled. For quack grass, the application should be made in the late spring, at the three to five leaf stage of development. For the control of grasses, in general, application should be at a stage of early growth when the entire site has a lush, green appearance. Roundup is applied at a rate of 2.2 kg active ingredient per hectare.
- where the prime target species are broadleaved perennials, application must occur at the early bud, pre-flowering stage. However, in most cases, quack grass is the primary target species. In certain cases, with combinations of quack grass and deep rooted perennials such as milkweed, it may be necessary to make two separate applications, one for each vegetative type. Roundup is applied at a rate of 2.2 to 3.3 kg active ingredient per hectare, depending on the species of broadleaved perennial to be controlled.

- deciduous woody vegetation is controlled by applications made in late spring; or in late summer to early fall, just prior to the formation of an abscission layer at the base of the leaf petiole, when translocation is actively occurring into the roots. Roundup is applied at a rate of 4.4 kg active ingredient per hectare.
- a period of 10 days should elapse after herbicide application before any mechanical operations are performed. The success of the application should be verified and if necessary, spot treatments or retreatments carried out.
- Roundup has no residual soil activity; tillage should commence as soon as the treatment success has been verified to prevent re-establishment of competition from germinating seeds.
- for situations where vegetation has passed the susceptible stage, the area can be brush cut and allowed to resprout. There must be sufficient time and appropriate growing conditions to allow for the necessary regrowth. In the case of quack grass, the area should be lush and uniformly green in colour. Spraying on brush cut stubble is ineffective. The brush cut resprout prescription tends to be less effective than an earlier Roundup application made at the proper stage
- Roundup applications during periods of vegetation dormancy (eg., hot dry periods) or following heavy, killing frosts are not effective.

The objective of tillage, subsequent to the Roundup treatment, is to loosen the soil in the plough layer, and thoroughly incorporate any organic matter. On sites where full tillage is not possible, some mechanical treatment such as discing or cultivation should be performed to break up the layer of dead vegetation that has accumulated on the surface. This layer tends to adsorb chemicals, signficantly reducing the effectiveness of Rising-O tending chemicals applied later.

It is critical to verify that the Roundup has been effective before any tillage is done. Once the area is ploughed, root systems are no longer connected to actively growing plants above ground. Since Roundup has no soil activity a considerable waiting period is required to ensure that all vegetation has emerged sufficiently so as to be treated. It may be necessary to make any further required treatments with Eptam instead.

7.7 Auger Holes for Long Rotation Plantations

Long rotation plantations for veneer are established using large rooted 2+0 planting stock as opposed to cuttings. Site preparation is performed differently as a result. The Roundup prescription is used to site prepare the area. Given the wide spacing of the plantation, site prepared strips, three metres wide, are adequate for planting. Auger holes are prepared in the spring at the time of planting using a tractor-mounted or hand-held post hole auger. Holes should be a minimum of 20 cm in diameter and one metre deep. The planting stock used is two-year-old trees, four to six metres in length with all roots and side branches pruned back close to the main stem. The Rising-O tending chemical is applied after planting.

7.8 Timeliness and Verification of Site Preparation Results

Best results are realized when operations are initiated as early as possible on each site. Most operations tend to be more effective when performed early in the season. An early start provides a greater range of treatment options and allows more time to react to unforseen circumstances. When verifying the success of treatments, surface and below surface inspections should be made. Root systems of the target vegetation should be examined to ensure the expected kill has occurred. If not, the situation needs to be re-evaluated and modifications made to the prescription.

The end result of site preparation should be the elimination of 100% of all competition on site, prior to planting. Effectiveness less than 80% cannot be considered acceptable. Perennials not eliminated prior to planting are virtually impossible to control thoroughly once the trees are in place, resulting in a continuing need for costly post-plant weed control measures. The best tending is good initial site preparation.

8.0 PLANTING

The density of the plantation at harvest is determined by the spacing at the time of planting. Clones are allocated to site on the basis of results from clone site trials. Planting is done using 25 cm long unrooted cuttings. Long rotation veneer plantations are established using large 2+0 stock planted in auger holes.

8.1 Management Systems and Markets

Hybrid poplar management systems are defined by density in stems per hectare and rotation age. Potential management systems represent a continuum from very high densities of thousands of stems per hectare, grown on short rotations, to low densities of several hundred stems per hectare, grown on long rotation. A management system is selected by first examining the potential markets and then determining the size and quality characteristics for the wood supply needed by each market. Once the specifications are known for the target market, an appropriate management system can be designed on the basis of Nelder and other spacing trial information to produce a tree of the required size. A comprehensive data bank is currently being developed, for a range of sites and clones, by the Fast Growing Hardwoods Staff Group at Brockville. The characteristics for the most commonly used management systems are given in Table 3. The name of each system reflects the planting density per hectare (eg., system 1K is approximately 1000 stems per ha).

TABLE 3

STANDARD HYBRID POPLAR MANAGEMENT SYSTEMS

Management System	Density (Stems/ha)	Rotation (years)	Mean Annual Increment (ODT*/ha)	Projected Yield at Harvest (ODT/ha)	Market
4K	4303	5	8.35	40.3	Pulp, Energy
1K	1077	10	6.41	64.1	Pulp
Long Rotation	250	20	4.18	83.6	Veneer

Site productivity and clone have a considerable effect upon the yield and length of rotation. For system 1K, rotations can range from eight to twelve years. Poor site preparation and subsequent weed control can seriously reduce yields and result in extended rotations in an attempt to regain lost productivity.

* Oven Dry Tonnes

8.2 Allocation of Clones to Site

The allocation of clones for the Province, is carried out centrally by the Allocation Committee, using a technology development package prepared by the Fast Growing Hardwoods Staff Group, Brockville. The planting areas are subdivided into regular shaped blocks, approximately two hectares in size, of relatively uniform soil types. Each block is then matched, by soil type, with the most similar clone site trial. Growth data from the trial is used to select the best available clone for planting on the block. To maximize the genetic diversity of each plantation, a single clone occupies a maximum of two hectares in a given plantation. The remaining blocks are matched with genetically unrelated clones. The maximum area which can be planted to a clone in any particular year is dictated by the amount of planting stock available and is further restricted to ten percent of the total hybrid poplar planting area in the Province.

8.3 Planting Stock

Planting stock consists of 25 cm long unrooted cuttings. Cuttings are produced from nursery-grown one-year-old whips during the dormant season. The material is graded by diameter as follows:

- small 6 - 10 mm
- medium 11 - 20 mm
- large 21+ mm

However, medium-sized cuttings are used almost entirely for plantation establishment. Cuttings are painted on their top ends and grouped into bundles of 25 with 500 cuttings packed per case. The material is packed in plastic bags to retain moisture and stored at -2° C to -4° C until planting. The material is kept frozen right up to the time of actual planting. Ideally the cuttings are planted while they are still frozen.

8.4 The Planting Operation

Planting commences in early spring as soon as the ground is sufficiently thawed to allow penetration of cuttings to a depth of 25 cm. A dibble bar approximately 1.5 cm in diameter is used to punch a 25 cm

deep hole in the soil. The cutting is pushed by hand into the hole, with the buds pointing upwards, so that the top of the cutting is flush with the soil surface. The dibble is pushed into the ground a second time, adjacent to the cutting, and is used to push the soil tightly against the cutting. Good contact between the cutting and the soil is important to eliminate air pockets and ensure good rooting. Care should be taken not to damage the top end of the cutting during planting. The resulting callus tissue will cause multiple shoots to initiate, instead of one main shoot.

Planting should be completed within 30 days of when the sites first became operable. Once soil temperature begins to rise and soil moisture levels drop below the saturation point, survival decreases rapidly.

Hand planting is relatively low cost and remains the only feasible means of planting given the saturated soil conditions in early spring. The rope method provides good control over the planting operation. Several planters are spaced along the rope at equal intervals and an individual at each end moves the top forward the exact spacing each time. Uniform spacing and straight rows must be maintained to facilitate future tending operations between the rows.

8.5 Performance Standards for New Plantations

The minimum standards of performance for plantations at the end of the first growing season are:

- 85% survival
- 1.3 m average height growth per planting spot

Refilling is not successful in plantations because of the rapid growth and highly competitive nature of the established trees. Plantations with poor survival should be considered failures and re-established completely.

8.6 Long Rotation Planting

Long rotation plantations for veneer production are the only cases where rooted stock is used for planting. The stock is grown for two years in the nursery. Prior to shipping to the planting site all side branches are removed, and the roots are pruned to within 10 cm of the main stem. Special care is required during handling of the stock to prevent breakage or damage. The trees are planted in one metre deep auger holes . The holes must be refilled completely and the soil well packed. Planting must

be done as early as possible in the spring prior to bud break on the stock. Broken leader tips should be pruned off at planting and seriously damaged stock discarded.

9.0 WEED CONTROL

Guidelines for weed control are as follows:

- Year 1 - 90% control of all competition.
- Year 2 - 80% control of all competition.
- Year 3 and older - 70% control of all competition to be maintained until the plantation is free-to-grow.

The percent control is on an area basis. Failure to maintain these levels of control will result in reduced plantation performance. Thorough weed control will maintain good growth and vigour. Lack of ground cover will prevent serious rodent damage. A plantation is considered free-to-grow when the trees are the dominant vegetation on the site and are no longer adversely affected by the presence of weed competition. Herbicides are consistently the most effective means of maintaining the necessary degree of weed control. As shifts occur in the weed spectrum, different herbicides, capable of controlling the new weed population, must be prescribed. It is essential that all herbicide treatments carried out in a plantation be documented, to facilitate calculation of residue levels in the course of developing later prescriptions.

9.1 Rising-O Tending

Site preparation, carried out in the Rising-O year (the year prior to planting), represents a considerable investment in the site. As soon as site preparation has been successfully completed weed control is necessary to prevent re-establishment of the competition and loss of the site preparation investment. Such competition can develop within days of the last treatment, and will not be controlled by pre-emergent herbicides most commonly used for Rising-O tending.

Herbicides for Rising-O tending should have a long half-life in the soils, to provide a long period of effective weed control. Simazine and terbacil are used primarily at this stage.

9.2 Tending in Rising-1 Plantations and Older

In plantations, weed control measures must be selected on the basis of the target weed species and the levels of herbicide residues present on the site. Because shifts in the weed spectrum are difficult to predict accurately, routine tending is not effective and is not an acceptable substitute for a proper monitoring and tending cycle (Figure 4). Shifts in the weed spectrum are influenced by: herbicide residues present on the site; the species of viable weed seeds present in the soil; the current weather conditions, as they affect seed germination; and breakdown of herbicide residues. Certain developments in weed competition may be anticipated:

- quack grass competition expands at an exponential rate regardless of the residual herbicide present on the site
- the application of a triazine herbicide such as simazine is generally followed by the development of a triazine resistant weed population eg., ragweed, old witch's grass.

The same herbicide is seldom applied twice in the same plantation because of these shifts in the weed spectrum. The directions for use, which include a listing of weeds controlled, should be followed as stated on the herbicide labels.

9.3 Brush Cutting

Annual weeds can often be eliminated by mechanical brush cutting prior to their flowering and the development of seed. Brush cutting should be followed with the application of a residual herbicide. Most annual weed problems tend to develop late in the growing season.

9.4 Roundup

Control with most perennials, including quack grass, can be achieved with Roundup. In all cases the vegetation must be actively growing. Quack grass is most effectively controlled by an application very early in the growing season. In addition to the "spring window", applications made during the "fall window" (early fall) can be quite effective if done prior to a killing frost.

Roundup is a non-selective, post-emergent herbicide. Severe tree damage and mortality will result if Roundup comes in contact with the tree crop. Application must be done as a shielded spray or with a roller

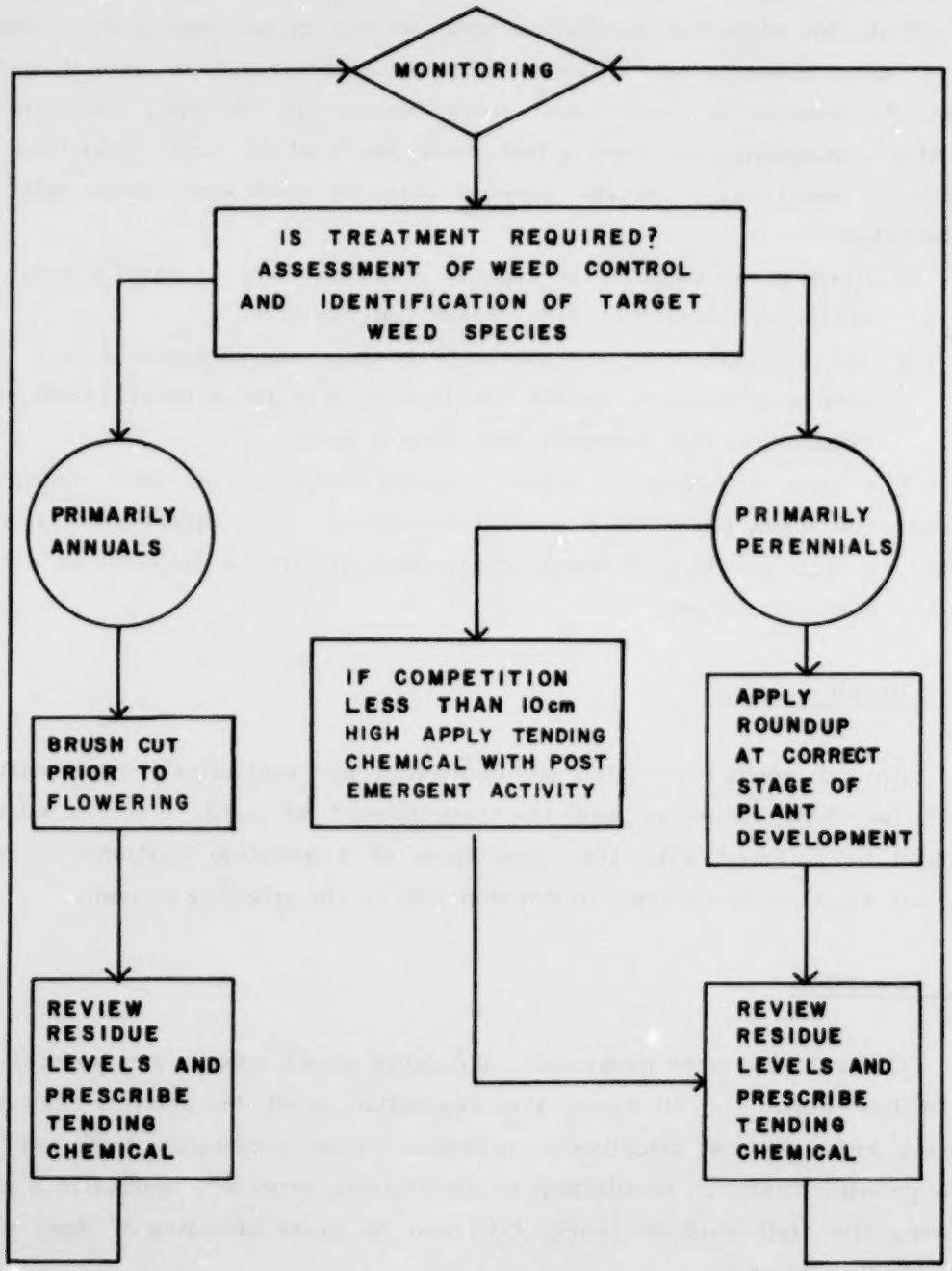
MONITORING
IS TREATMENT REQUIRED? ASSESSMENT OF WEED CONTROL AND IDENTIFICATION OF TARGET WEED SPECIES
PRIMARILY ANNUALS
PRIMARILY PERENNIALS
BRUSH CUT PRIOR TO FLOWERING
IF COMPETITION LESS THAN 10cm HIGH APPLY TENDING CHEMICAL WITH POST EMERGENT ACTIVITY
APPLY ROUNDUP AT CORRECT STAGE OF PLANT DEVELOPMENT
REVIEW RESIDUE LEVELS AND PRESCRIBE TENDING CHEMICAL
REVIEW RESIDUE LEVELS AND PRESCRIBE TENDING CHEMICAL

Figure 4. Monitoring and tending cycle for plantations not free-to-grow

or wick-type applicator. The normal rate of application is 2.2 kg active ingredient per hectare.

A residual herbicide should be applied immediately after the Roundup treatment since the Roundup provides no residual soil activity.

9.5 Residual Herbicides

Residual herbicides persist in the soil for a period of time providing long term weed control. Herbicides must be selected on the basis of the target weed species to be controlled and the presence of previously applied herbicide residues. The rate of application is based upon the soil texture of the site. This rate may have to be reduced if, from previous applications, significant amounts of residue of the same herbicide remain on the site. Residue levels are estimated according to the dates and rates of previous applications, and the half-life or persistence of the herbicide. At no time should the level of residues in established plantations exceed the recommended application rate for hybrid poplar.

Information on herbicides suitable for tending hybrid poplar is summarized in Table 4. More complete information is published, on the actual herbicide label, with respect to specific weed species controlled and conditions for use.

9.6 Dual Cropping

Widely-spaced, long rotation plantations may be tended by dual cropping. Instead of using residual herbicides, agricultural crops such as corn, potatoes or other vegetables are planted and tended between the rows. These crops make more complete use of the site and provide an annual cash flow, and as the crops are tended, the trees are also tended. After four to five years, shading from the trees begins to reduce crop yields significantly. As this occurs, the emphasis shifts to the establishment of a cover crop such as alfalfa or clover. Cover crops continue to provide weed control; legumes chosen for this purpose provide an additional benefit by fixing nitrogen on the site.

In dual crop areas, the agricultural crop is often fertilized. The tree crop also benefits from this treatment.

TABLE 4

RESIDUAL HERBICIDES FOR TENDING HYBRID POPLAR

Herbicide Common Name	Type of Action	Primary Target Vegetation	Persistence* Half Life in Soil	Application Rates (kg/ha a.i.)** Clay Loam	Sandy Loam
Simazine	Pre-emergent	Germinating broadleaf weeds and grasses	12 months	5.0	4.0
Terbacil	Pre-emergent	Many annuals and some perennial broadleaved weeds and grasses	6 months	2.25	1.7
Diuron	Pre-emergent; Post-emergent with surfactant, if weeds 5cm high	Selective; broadleaves and grasses	Persistent up to one season	2.0	1.5
Alachlor	Pre-emergent and early post-emergent	Most annual grasses and certain broadleaves	Persistent 6 to 10 weeks	4.0	4.0
Diphanamid	Pre-emergent	Annual grasses and broadleaves	Persistent 3 to 6 months	4.0	4.0
Cyanazine	Pre-emergent	Annual grasses and broadleaves	2 weeks	2.25	2.25
Metribuzin	Pre-emergent; or early post-emergent, if weeds 3cm high	Annual grasses and broadleaves	2 to 4 weeks	1.5	1.5
Linuron	Pre-emergent; post-emergent with surfactant, if weeds 12.5 cm high	Germinating broadleaved weeds and grasses	Persistent up to one season	2.0	1.5

*Persistence - length of time phytoxic activity will occur
Half Life - period of time required for one half of the applied amount to break down on the site
** a.i. - active ingredient

10.0 PEST MANAGEMENT

To minimize the impact of pests, the amount of genetic diversity within a plantation is maximized. New clones are continually introduced for planting and older clones with poorer performance are rogued out. This strategy avoids the need for routine spraying of fungicides and insecticides. Proper matching of clones to sites results in vigorous, fast-growing plantations, which are less susceptible to pests, eliminating the need for expensive and environmentally dangerous insecticides and fungicides.

A number of surveys have been conducted in production plantations to identify the insects and diseases present. The presence and severity of the impact varies widely from clone to clone and depends heavily upon the site. All clonesite trial areas are surveyed on an annual basis for the presence of insects, diseases and frost damage. High risk clones are identified at this stage rather than after substantial areas of production plantation have been established.

The principal insects and diseases known to occur in plantations are listed in Appendix 1. The need for, and details of, any proposed control program should be discussed with the Fast Growing Hardwoods Staff Group at Brockville.

10.1 Physical Factors

Frost is occasionally a damaging agent. Clones susceptible to frost damage are identified and are not allocated for planting on high risk sites. Frost damage can cause growth deformities and provide entrance courts for diseases. Young trees are susceptible to hail damage; hail stones cause lesions on stems and shred foliage.

11.0 PRUNING

Pruning is practiced only in long rotation plantations where high quality veneer will be the end product. Multiple leaders are thinned to one dominant leader. Pruning is carried out to limit knots and defects to a small core in the center of the tree. It should be initiated while the trees are still very young, and repeated at frequent intervals until eight meters of clear bole length has been established. Pruning operations should be timed for the dormant season (late winter). Branches in the lower third of the crown, below the widest part of the crown can be removed. Fastest healing of the cut surfaces will occur if the pruning cut is clear and not completely flush with the bole; approximately two centimetres of a stub should be left.

On vigorous trees, pruning cuts should completely heal themselves over in one growing season. The removal of live healthy branches will cause a slight reduction in growth. The need for quality must be weighed against the potential reduction in growth.

12.0 HARVESTING

Harvesting should be carried out carefully to minimize damage to the site. Harvesting during the dormant season leaves most of the foliage and therefore many of the nutrients, on the site for the next rotation. Stumps should be cut smoothly and fairly flush with the ground. Care should be taken to protect the stump since its quality will affect the development of coppice shoots.

Several options exist for harvesting hybrid poplar. System IK can be harvested using a small feller buncher, and grapple skidder. A mobile chipper on site breaks down the material and blows the whole tree chips into a van for pulp or energy. Chainsaw felling can also be used. However, the uniform size and even-spacing of the trees, and the level terrain, provide ideal conditions for mechanized harvesting. Whole tree chipping leaves very little slash and debris on the site, and provides good conditions for the regeneration of the stand.

13.0 COPPICE MANAGEMENT

Experience elsewhere has shown that increased yields are obtained following the first harvest, through coppice management. It is anticipated that up to three harvests can be made from the same root system. Aspen-type clones reproduce predominately by root suckers and will require a different management approach. The quality of the coppice stand will be directly influenced by the success of management practices used during the first rotation and the resultant quality and vigour of the stand prior to harvest.

14.0 MARKETS

The initial interest in growing hybrid poplar was for producing pulp. More recently, a number of other potential uses have been identified:

- energy
- waferboard
- particleboard and hardboard

- dimensional lumber (produced by slicing, drying and gluing wood segments)
- veneer
- plywood
- pulp and paper
- food products such as artificial sweeteners and vitamin C.

15.0 ADDITIONAL INFORMATION AND BIBLOGRAPHY

General Science of the Program:

- Armson, K.A. 1983. New Forests in Eastern Ontario (Hybrid Poplar). Ontario Ministry of Natural Resources. (In Press)

The scientific review publication documents the scientific basis for the program and can be referred to for further information and references. It is comprised of the following ten papers:

- The Genetic Resource; (the clones used in the program)
- Growth, Density and Time; (spacing and design of management systems)
- Soils: The Forest Foundation; (soils and soil surveying)
- Genes and Diversity; (matching clones to site)
- Nursery Production of Fast Growing Hardwoods; (nursery practices)
- Setting out the Crop; (site preparation and weed control)
- Cultual Practices; (drainage, dual cropping, use of sludge)
- Harvest and Yield; (yield and volume tables)
- The Producer; (economics)
- The Consumer; (wood supply scenarios)

In addition, the following sources of information are recommended:

The Genetic Base:

For a complete listing of all willow and poplar clones in Canada:

- Ronald, W.G. (ed.) 1982. Register of Populus and Salix. Poplar Council of Canada, 123 pp.

Soils:

The "Soils Technology Development Package" documents the soil survey procedures and the basis of soils for the program. This is currently being prepared and scheduled for publication in 1983, with K.A. Armson as editor.

Site Preparation and Weed Control:

For detailed technical information on herbicides:

- Weed Science Society of America. 1979. Herbicide handbook. 4th Ed. Weed Science Society of America, Champaign, Illinois. 479pp.

For general information on chemical weed control, effectiveness rating for chemicals against various target weeds, sprayer calibration:

- Ontario Ministry of Agriculture and Food. 1983. Guide to chemical weed control. Pub. No. 75. 156 pp (This publication is revised and republished annually).

Pest Management:

For a review of diseases affecting hybrid poplar:

- Hubbes, M. 1979. Disease survey in hybrid poplar plantations and nurseries in Ontario. On-file Rep. #79-DI-2. 30 pp. (prepared under contract for the Ontario Ministry of Natural Resources.)

For a review of insects affecting hybrid poplar:

- Morris, R.C. 1981. Insects of native and hybrid poplars (Populus spp.) in North America. Pest Control Rep. No. 11, Ontario Ministry of Natural Resources.

Growth and Yield:

A growth and yield publication is currently being prepared for hybrid poplar and is scheduled for publication in 1983 with K.A. Armson as editor.

Utilization:

- Forintek Canada Corp. 1980. Development of utilization data on hybrid poplar to provide guidance in forest management. Report prepared for Ontario Ministry of Natural Resources. 115 pp.

- Forintek Canada Corp. 1981. Further data on properties and utilization potential of Ontario's hybrid poplars. Report prepared for Ontario Ministry of Natural Resources. 131 pp.

APPENDIX 1

Principal Insects and Diseases Occurring in Hybrid Poplar Plantations

Common Name	Scientific Name
• Insects	
Poplar Leaf Roll Midge	Prodiplosis morrisi
Willow Shoot Sawfly	Janus abbreviatus
Cottonwood Leaf Beetle	Chrysomela scripta
Poplar and Willow Borer	Cryptorrhynchus lapathi
Vagabond Aphid	Mordwilkoja vagabunda
Leaf-folding Sawfly	Phyllocolpa bozemani
Imported Willow Leaf Beetle	Plagiodera versicolora
Spiney Elm Catepillar	Nymphalis antiopa
Cottonwood Twig Borer	Gypsonoma haimbachiana
• Diseases	
Bacterial Canker	Erwinia spp.
Cytospora Canker	Cytospora chrysosperma
Dothichiza Canker	Dothichiza populea
Melampsora Leaf Rust	Melampsora medusae
Septoria Canker and Leaf Spots	Septoria musiva
"Unknown Disease" *	
• Physical Factors	
Sunscald (and subsequent attack by decay fungi such as Polyporus pargamenus)	
Frost Cracks	
Herbicide Damage	

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* "Unknown disease" has not been positively identified, but is confined to aspen-type hybrids where it causes brown discolouration of the leaves in the upper crown.

APPENDIX 2

Glossary of Selected Technical Terms Associated with Hybrid Poplar

Clone: A stock of individual plants reproduced asexually from a common ancestor and, therefore, genetically identical.

Clone Site Trial: A well-designed statistically sound trial in which a number of clones are established on a uniform site, with the objective of determining which clone or group of clones is most productive on that particular soil.

Cultivar: A "cultivated variety" is a clone with outstanding characteristics making it desirable for cultivation. Usually it is assigned a specific name. eg., "Allenstein" or 'DN 1'.

Dead Furrow: A narrow strip of land which remains unploughed and is covered by a furrow as the first ploughing is done on the land. The number of dead furrows is minimized by using fewer lands.

Free-to-grow: The stage at which the tree crop is the dominant vegetation on the site, and no longer suffers significant growth reductions from competing vegetation.

Hybrid: An offspring produced by a cross of two genetically dissimilar parents of the same species, or by two parents of two different species. In many cases the offspring displays considerable hybrid vigour, surpassing the parents in many characteristics.

Nelder Trial: A systematic spacing trial which provides information on the influence of density on individual tree size.

Post-emergent herbicide: A herbicide which must be applied after the target species has emerged from the soil, eg., linuron with a surfactant.

Pre-emergent herbicide: A herbicide which must be applied prior to the emergence of the target species from the soil, eg., simazine.

Residue Management: The maintenance and use of records listing the rates and dates of all herbicides applied to a site which, when combined with knowledge of herbicide half-lives, allows the estimation of the level of herbicide residues remaining on a site.

Rising-O, or R-O: The year prior to planting.

Rising-x, or R-x: Refers to the current growing season of a particular stand, eg., Rising-1 refers to a stand in its first growing season. This includes the period from initiation of growth in the current season to just prior to initiation of growth in the following season.

Strike-out: A strike out is a single pass of the plough made across a field to divide it into several evenly sized blocks or "lands".

Target Species: The principal weed species or group of species which is the focus for herbicide use, and which is causing competition to the planted tree crop, eg., quack grass.

Weed Spectrum: The range of weed species and species groups which can occupy a particular site at any point in time.